Claims

[c1] *1* .A light source comprising:

a light emitting semiconductor device; and

a support substrate having a generally planar reflective surface that supports the semiconductor device, the light emitting semiconductor device heat sinking via the support substrate; and

a curved reflector having a concave parabolic reflective surface, the light emitting semiconductor device arranged between the generally planar reflective surface and the concave parabolic reflective surface, the support substrate and the curved reflector together defining a light aperture through which light produced by the light emitting semiconductor device passes.

[c2] *2* .The light source as set forth in claim *1* , wherein the planar reflective surface and the concave parabolic reflective surface cooperate to reflect light produced by the light emitting semiconductor device that is directed toward one of the planar reflective surface and the concave parabolic reflective surface toward the light aperture along a direction generally parallel to an optical axis of the concave generally parabolic surface.

[c3] *3* .The light source as set forth in claim *1* , wherein an optical axis of the concave generally parabolic surface coincides with the planar reflective surface.

[c4] *4* .The light source as set forth in claim *1* , wherein the light emitting semiconductor device is centered at an optical focus of the concave generally parabolic surface.

[c5] *5* .The light source as set forth in claim *1* , wherein the light emitting semiconductor device is positioned with a first edge substantially aligned with an optical focus of the concave generally parabolic surface, the light emitting semiconductor device extending from the first edge away from the light aperture.

[c6] *6* .The light source as set forth in claim *1* , wherein the light emitting semiconductor device is positioned with a first edge substantially aligned with an optical focus of the concave generally parabolic surface, the light emitting

semiconductor device extending from the first edge away from the optical focus along an optical axis of the concave generally parabolic surface.

[c7] *7*.The light source as set forth in claim *1*, wherein the curved reflector includes:
a light transmissive encapsulant that encapsulates the light emitting semiconductor device and at least a portion of the generally planar reflective surface, the encapsulant including a convex generally parabolic encapsulant surface; and
a reflective layer disposed on the convex generally parabolic encapsulant surface, an interface between the reflective layer and the encapsulant corresponding to the concave generally parabolic surface of the curved reflector.

[c8] *8*.The light source as set forth in claim *7*, wherein the light transmissive encapsulant includes a light transmissive refractive surface coinciding with the light aperture, the refractive surface refracting light produced by the light emitting semiconductor device as it passes through the light aperture.

[c9] *9*.The light source as set forth in claim *8*, wherein the light transmissive refractive surface defines a lens that focuses the light passing through the light aperture to a focal point.

[c10] *10*.The light source as set forth in claim *8*, wherein the light transmissive refractive surface is generally planar, and a surface normal of the light transmissive refractive surface is arranged at a non-zero angle with respect to an optical axis of the parabolic reflector.

[c11] *11*.The light source as set forth in claim *1*, wherein the light emitting semiconductor device is a light emitting diode having a direction of strongest light emission directed perpendicularly to the generally planar reflective surface and away therefrom.

[c12] *12*.The light source as set forth in claim *1*, wherein the light emitting semiconductor device and the curved reflector define a light emission module, the light source including a plurality of light emitting modules arranged on the

support substrate.

[c13] *13*.The light source as set forth in claim *1*, wherein the light emitting semiconductor device, the curved reflector, and the support substrate define a light emission module, the light source further including:
a support structure;
a plurality of first light emission modules arranged on the support structure and emitting light directed away from the support structure at a first angle; and
a plurality of second light emission modules arranged on the support structure and emitting light directed away from the support structure at a second angle different from the first angle, the second light emission modules being interspersed among the first light emission modules.

[c14] *14*.The light source as set forth in claim *13*, further including:
a power circuit that selectively supplies power to one of the first light emission modules and the second light emission modules to produce one of a first beam directed at the first angle and a second beam directed at the second angle, respectively.

[c15] *15*.The light source as set forth in claim *1*, wherein the light emitting semiconductor device includes a monolithic array of light emitting semiconductor device elements, the support substrate includes the monolithic substrate, and the curved reflector includes a plurality of curved reflectors corresponding to the light emitting semiconductor device array elements, the light source further including:
a plurality of encapsulant forms corresponding to the light emitting semiconductor device array elements, each encapsulant form encapsulating the corresponding light emitting semiconductor device array element and including a curved surface defining a curvature of the curved reflector.

[c16] *16*.The light source as set forth in claim *15*, wherein the elements of the light emitting semiconductor device array are selected from a group consisting of light emitting diodes and vertical cavity surface emitting lasers.

[c17] *17*.A headlight for a vehicle, the headlight comprising:

a support surface; and

a plurality of light emission modules each including:

a reflective cup including a planar portion and a parabolic portion joined together at a parabolic interface, an open end of the parabolic portion defining a light output opening, and

a light emitting semiconductor die attached to the planar portion of the reflective cup and oriented to produce light directed toward the parabolic portion of the reflective cup,

wherein the light emission modules are arranged on the support surface with the planar portion of each reflective cup parallel to the support surface and the light output openings of the reflective cups arranged such that the plurality of light emission modules produce a cumulative light beam.

[c18] *18*.The headlight as set forth in claim *17*, wherein each light emission module further includes:

a light-transmissive material that fills the reflective cup and seals the light emitting semiconductor die.

[c19] *19*.The headlight as set forth in claim *18*, wherein the parabolic portion of the reflective cup includes a reflective film disposed on the light-transmissive material.

[c20] *20*.The headlight as set forth in claim *17*, wherein the plurality of light emission modules include:

low beam light emission modules that produce light directed at a low beam angle relative to a parabolic axis of the parabolic interface; and

high beam light emission modules that produce light directed at a high beam angle relative to the parabolic axis of the parabolic interface, the high beam angle being smaller than the low beam angle.

[c21] *21*.The headlight as set forth in claim *20*, wherein the light emitting semiconductor die of each low beam light emission module has an edge aligned with a focus of the parabolic portion of the reflective cup and extends laterally away from the light output opening along the planar portion of the reflective cup.

[c22] *22*.The headlight as set forth in claim *20*, wherein the light emitting semiconductor die of each high beam light emission module is centered at a focus of the parabolic portion of the reflective cup.

[c23] *23*.The headlight as set forth in claim *20*, wherein each light emission module further includes:
a light-transmissive encapsulant material filling the reflective cup, the light transmissive material having a light-transmissive surface at the light output opening, the light transmissive surface being orthogonal to the planar portion of the reflector cup for the high beam light emission modules and the light transmissive surface being tilted downward from orthogonal to the planar portion of the reflector cup for the low beam light emission modules.

[c24] *24*.The headlight as set forth in claim *17*, wherein the support surface is a portion of a heat sink and the reflective cups are thermally conductive to provide heat sinking of the light emitting semiconductor dice.

[c25] *25*.The headlight as set forth in claim *17*, wherein the support surface and the reflective cups are thermally conductive and the support surface is disposed on a bumper of the vehicle, the bumper serving as a heat sink for the headlight.

[c26] *26*.A solid-state light source including:
a solid-state light emitting device; and
a reflector including a generally planar side and a generally concave curved side facing the generally planar side, the solid-state light emitting device supported by the generally planar side and emitting light generally directed toward the concave curved side, the reflector further including an opening defined by edges of the generally planar side and the generally concave curved side toward which the generally planar side and the generally concave curved side cooperatively direct light produced by the solid-state light emitting device.

[c27] *27*.The solid-state light source as set forth in claim *26*, further including:
a translucent or transparent filling material filling the reflector and having an light-transmissive surface disposed at the reflector opening.

[c28] *28*.The solid-state light source as set forth in claim *27*, wherein the light-

transmissive surface defines a lens for focusing the light.

[c29] *29*.The solid-state light source as set forth in claim *27*, wherein the light-transmissive surface is arranged at a non-perpendicular angle to the generally planar side to refractively tilt the light.

[c30] *30*.The solid-state light source as set forth in claim *26*, wherein the generally concave curved side defines a half-parabolic reflector.

[c31] *31*.The solid-state light source as set forth in claim *30*, wherein a parabolic axis of the half-parabolic reflector lies on or near the generally planar side.

[c32] *32*.The solid-state light source as set forth in claim *30*, wherein the solid-state light emitting device is arranged asymmetrically along the parabolic axis respective to a focal point of the half-parabolic reflector such that an asymmetrical beam pattern with a sharp cutoff is produced by the solid-state light source.

[c33] *33*.The solid-state light source as set forth in claim *26*, wherein the generally planar side and the generally concave curved side cooperatively direct light produced by the solid-state light emitting device parallel to the generally planar side.

[c34] *34*.The solid-state light source as set forth in claim *26*, wherein the generally planar side of the reflector provides primary heat sinking for the solid-state light emitting device.

[c35] *35*.A method for manufacturing a light source, the method including:
securing a light emitting semiconductor die to a reflective planar surface;
applying an encapsulant over the light emitting semiconductor die to seal the die, the applying defining an encapsulant surface having an aperture side and a curved side; and
applying a reflective layer to the curved side of the encapsulant.

[c36] *36*.The method as set forth in claim *35*, wherein the applying of an encapsulant includes:
arranging a mold defining at least the curved side of the encapsulant onto the

reflective planar surface to define a mold cavity;
disposing the encapsulant in a liquid or flowing solid form into the mold cavity; and
removing the mold after the encapsulant has solidified.

[c37] *37*.The method as set forth in claim *36*, wherein the applying of an encapsulant further includes:
polishing the aperture side of the solidified encapsulant to define a selected refractive surface.

[c38] *38*.The method as set forth in claim *35*, further including:
repeating the steps of securing a light emitting semiconductor die, applying an encapsulant, and applying a reflective layer for a plurality of light emitting semiconductor dice to define a linear light source array.

[c39] *39*.The method as set forth in claim *35*, wherein the curved side of the encapsulant surface has a paraboloid curvature.

[c40] *40*.The method as set forth in claim *35*, wherein the step of applying a reflective layer includes:
depositing a metal layer on the curved side of the encapsulant surface.

[c41] *41*.The method as set forth in claim *40*, wherein the step of applying a reflective layer further includes:
prior to depositing a metal layer, masking the aperture side of the encapsulant to prevent metal deposition thereon during the depositing.

[c42] *42*.The method as set forth in claim *35*, wherein the reflective planar surface includes a high thermal capacity to provide heat sinking for the light emitting semiconductor die.